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Box Patent Application

Transmitted herewith for filing is the patent application of

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Dirk RODE and Hector VILLANUEVA**

For : **LIQUID-COOLED CASTING DIE**

Enclosed are:

1. 6 sheets of specification, 3 sheets of claims, and 1 sheet of abstract.
2. 2 sheets of drawings.
3. Continuing application information:

This application is a continuation of prior application No.
09/237,803 filed January 27, 1999.

4. Other enclosures:
 - a) Return Receipt Postcard
 - b) Certified copy of German Patent Applications 198 02 809.1 filed January 27, 1998 on which priority is based.
 - c) Four Month Extension Of Time

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5. The filing fee has been calculated as shown below:

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Dated: 8/11/99

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LIQUID-COOLED CASTING DIE

BACKGROUND OF THE INVENTION

Field of the Invention

5 The invention relates to a liquid-cooled casting die for a continuous casting installation having a form-giving casting die body made of a material of high thermal conductivity, such as copper or a copper alloy.

10 Description of Related Art

 Casting dies are designed to remove heat from the molten metal and to make it possible for the billet to solidify all the way through, beyond the casting shell that forms at the outset.

15 Various casting die geometries are in use, depending on the application, such as casting die tubes in round, rectangular, or complex shapes. Casting die plates are used for square/rectangular cogs [cogged ingots] or for slabs
20 having greater height-width ratios. In addition, there are special geometries, such as preliminary sections for double-T supports and thin-slab casting dies having funnel expansion in the upper plate area for receiving the pouring nozzle. It is characteristic of all these casting dies that their goal is a
25 homogeneous cooling of the surfaces. The corner areas represent special cases since in plate-type casting dies, by virtue of the design, there are, for example, abutting edges having disrupted cooling. In addition, there are some areas having larger material volumes for the reverse-side mounting
30 elements, the areas, with a view to identical cooling, being adjusted at the start using specially configured groove-shaped coolant channels.

It is also known to provide improved cooling to casting dies subject to particularly high thermal stresses, in order to avoid premature damage to the casting die. This means in the case of thin-slab casting dies, for one thing, that the thermal resistance of the casting die wall should not be too great, for which reason thinner walls are chosen. For another thing, given the higher pouring rates that are aimed at, particular demands are placed on cooling-water quality and flow rate.

All of the cited measures have the same goal, to provide the pouring side of the casting die body with the best possible, homogeneous cooling. Potential areas of disruption due to the type of construction, such as at reverse-side cooling surfaces, are eliminated when the occasion arises, in order to obtain once again a uniform cooling.

For one thing, the local conditions of stress in the use of funnel casting die plates are dependent on the operating conditions. On the pouring side, they are basically determined by the kind of steel/pouring temperature, the speed, the lubrication/cooling conditions of the pouring powder, the geometry of the pouring nozzle, and the corresponding flow of the molten mass. On the other side, the water side, the casting die temperatures are determined by the quality, quantity, and flow rate of the cooling water. These variables are partly determined already by the casting die design, such as in the geometry of the coolant channels.

Using the destructive test of numerous casting die plates in use in various steel mills, however, the actual stressing and also the damage resulting thereby of the casting die material can be clearly determined. On the basis of these tests, a varying weakening of the surface and of the area near the surface extending across the width of the meniscus can be

established.

Thus, in the critical area, the hardness falls from 100 % of the output value to approximately 60%, whereas at the same level near the critical area, only a fall of approximately 70% of the output hardness is measured; in this context, the edge area of the casting die plates does not come into consideration. Similar results are yielded by measurements of the wall thickness after use of the casting die plates; identical material weaknesses in the critical area of the bath surface extending across roughly one-third of the greater depths in comparison to the uncritical areas.

Thin-ingot casting dies are stressed to different extents as a result of the varying influences on the broad side walls. Among these influences are essentially:

- a high flow rate of the steel molten mass; turbulence of the molten mass particularly stresses the transitional areas of the funnel into the plane-parallel sides of the casting cross-section.
- a higher mechanical stressing of the wall of the copper plate bent in the funnel discharge as a result of thermal expansion. The resulting stresses are particularly high on the pouring side.

This leads to a particularly pronounced softening of the casting die material in this transitional area of the funnel. As a result of the locally relatively higher temperatures and the higher material loads related to the respective resistance to heat of a material-volume element, cracks can appear prematurely in this surface area. These cracks are the more likely to occur due to a diffusion process, marked here as temperature dependent, of Zn-atoms from the steel into the Cu-

matrix, because the Cu-Zn phases which arise form a hard and brittle surface layer which makes possible higher rate of crack formation.

SUMMARY OF THE INVENTION

It is an object of the invention to create a casting die body in which the heat flow is raised in the bath surface area, and the danger of the formation of cracks in the thermally and mechanically more stressed areas can be avoided.

These and other objects of the invention are achieved by a liquid-cooled casting die for a continuous casting installation, having a form-giving casting die body made of a material of high heat conductivity such as copper or a copper alloy, wherein the casting die body, on the cooling-surface side in the more thermally and mechanically stressed areas, has a cooling zone having a greater rate of heat flow relative to the surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail in the following detailed description of the preferred embodiment in conjunction with the accompanying drawings, in which:

Fig. 1 is a casting die plate in accordance with the invention; and

Fig. 2 is a detailed view of the pouring side of the casting die plate, showing cooling grooves.

DETAILED DESCRIPTION OF THE INVENTION

The crux of the invention is the feature of putting into place a significantly stronger cooling of the casting die body in the supercritically stressed areas on both sides of the funnel. According to the invention, it is proposed to increase the cooling capacity in these critical areas preferably 10 to 20% in relation to the horizontal adjoining areas. Coolant

channels, for example, can be advantageously made narrower here, so that the cooled surface is made larger. Alternatively, the coolant channels can be brought closer to the surface locally; in this case, the system operates, in an unusual fashion, with varying -- effectively active -- cooling wall thicknesses above the cooling water. The same applies to the cooling bore holes. In addition, broad-side plates, configured having groove-shaped coolant channels, in the critical areas of the funnel transition can be provided with additional cooling bore holes; in a surprising manner, in spite of the small wall thickness, the resistance to cracks of the casting die material is increased also here and with it the overall durability of the casting die plate.

Moreover, on the basis of varying cooling intensities on the reverse side, a significantly smoother temperature profile is achieved on the pouring side of the plate surface. This effect makes possible a smaller temperature interval for a sensible, narrower operating temperature range of the pouring powder. Thus the adjustment of the pouring powder to a colder or hotter temperature range can be avoided.

Below, the invention is explained in greater detail on the basis of the exemplary embodiments presented in the drawings.

Funnel casting die plate 1, represented in Figure 1, in the horizontal dimension (vertical line C) of funnel 2 on the pouring side, has the highest thermal stressing. A direct consequence is a maximum surface-related heat flow of 4.7 to 5.2 and MW/m² lying directly beneath bath surface 3 at C in the pouring direction GR. Present on pouring side 4 of casting die plate 1 are maximum temperatures of approximately 400°C, calculated by computer. Actively effective wall thickness d of casting die plate 1 of copper is now reduced in critical area

5 between the lines B, C, and D, to the upper 200 mm of the casting die plate from $d_1 = 20$ mm to $d_2 = 18$ mm (Figure 2).

Thus a maximum surface temperature this reduced by 28°C is achieved; this preferred cooling is maintained given appropriate reworking of casting die plate 1. Although the wall thickness d_2 in critically stressed area 5 is 2 mm smaller, the result, surprisingly, is still a generally greater service lifetime of casting die plate 1, including reworking. Area 5, which is more intensively cooled due to cooling grooves 6 that are placed deeper (wall thickness between pouring and cooling surface 18 mm instead of 20 mm), extends, in the present case, over the following surfaces (see Figure 1): the horizontal length from turning point B of funnel 2 more than 370 mm to end point D. The more intensive cooling surface extends from plate upper edge 7 up to 200 mm in the pouring direction GR; adjoining is a transitional zone 8 of 50 mm, in which the depth d of cooling grooves 6 is adjusted.

WHAT IS CLAIMED IS:

1. A liquid-cooled casting die for a continuous casting installation, comprising: a form-giving casting die body made of a material of high heat conductivity, the casting die body having a cooling-surface side in thermally and mechanically stressed areas thereof, wherein the casting die body has a cooling zone on said cooling-surface side, said cooling zone having a greater rate of heat flow relative to the surface.

2. The casting die body as recited in claim 1, wherein the form-giving casting die body is made of copper or a copper alloy.

3. The casting die as recited in claim 1, which includes a die cavity which is composed of two broad-side walls situated opposite each other and narrow-side walls limiting the width of the billet.

4. The casting die as recited in claim 3, wherein the cross-section of the die cavity at the pouring-in-side end is greater than at the billet-exit-side end.

5. The casting die as recited in claim 3, wherein the die cavity, at the pouring-in-side end, has at least one hollow space, which can become smaller in the pouring direction (GR).

6. The casting die as recited in claim 1, wherein the cooling zone having a greater surface-related heat flow is arranged in the bath surface area, the cooling zone extending to at least 20% of the length of the meniscus of the broad-side wall.

7. The casting die as recited in claim 6, wherein the cooling zone having a greater surface-related heat flow is

arranged in the bath surface area, the cooling zone extending to 30-60% of the length of the meniscus of the broad-side wall.

8. The casting die as recited in claim 1, wherein the surface-related heat flow in the more stressed area of the bath surface is 5-40% greater than in the other areas of the bath surface.

9. The casting die as recited in claim 8, wherein the surface-related heat flow in the more stressed area of the bath surface is 10-20% greater than in the other areas of the bath surface.

10. The casting die as recited in claim 1, wherein the wall thickness between the pouring and cooling surface is reduced in the thermally and mechanically stressed areas of the broad-side walls.

11. The casting die as recited in claim 10, wherein the wall between the pouring and the cooling surface in the bath surface area has a thickness that is reduced by 1 to 6 mm.

12. The casting die as recited in claim 1, wherein the casting die body has, running parallel to the pouring direction, a groove-shaped coolant channel or cooling bore holes, which in the thermally and mechanically stressed areas are configured narrower.

13. The casting die as recited in claim 12, wherein the spacing of the coolant channels or cooling bore holes in the thermally and mechanically stressed areas is at least 20% less than in the horizontal adjoining areas of the bath surface.

14. The casting die as recited in claim 12, wherein the coolant channels or the cooling bore holes are arranged in a transitional area so as to become gradually narrower.

15. The casting die as recited in claim 12, wherein between the coolant channels, additional cooling bore holes are arranged.

Abstract of the Disclosure

A liquid-cooled casting die for the continuous casting of thin steel slabs has a molding casting die body made of a material of high heat conductivity, such as copper or a copper alloy. Preferably the casting die body is made, in each case, of two broad-side walls, situated facing each other, and narrow-side walls limiting the width of the billet, the broadside walls forming a funnel-shaped pouring-in area. In order avoid the formation of cracks in the thermally and mechanically more stressed areas of the copper plate, cooling zones are arranged particularly in the bath surface area having higher surface-related heat flow.

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Fig. 1 a) is a plan view of a rectangular structure. The overall width is 1000 and the overall height is 200. A central vertical dashed line is labeled 'A'. The structure is divided into four vertical sections labeled B, C, D, and E from left to right. The top edge is labeled '7'. The bottom edge is labeled '4'. The right edge is labeled '3'. The top-left corner is labeled '5'. The top-right corner is labeled '8'. A dimension of 370 is indicated for the width of the rightmost section. A dimension of 50 is indicated for the height of the top-left corner. A downward arrow labeled 'GR' is shown on the right side.

Fig. 1 b) is a cross-sectional view of the structure. It shows a curved profile with points A, B, C, D, and E marked along the bottom edge. The top edge is labeled '1'. The bottom edge is labeled '4'. The right edge is labeled '5'. The profile is labeled '2'.

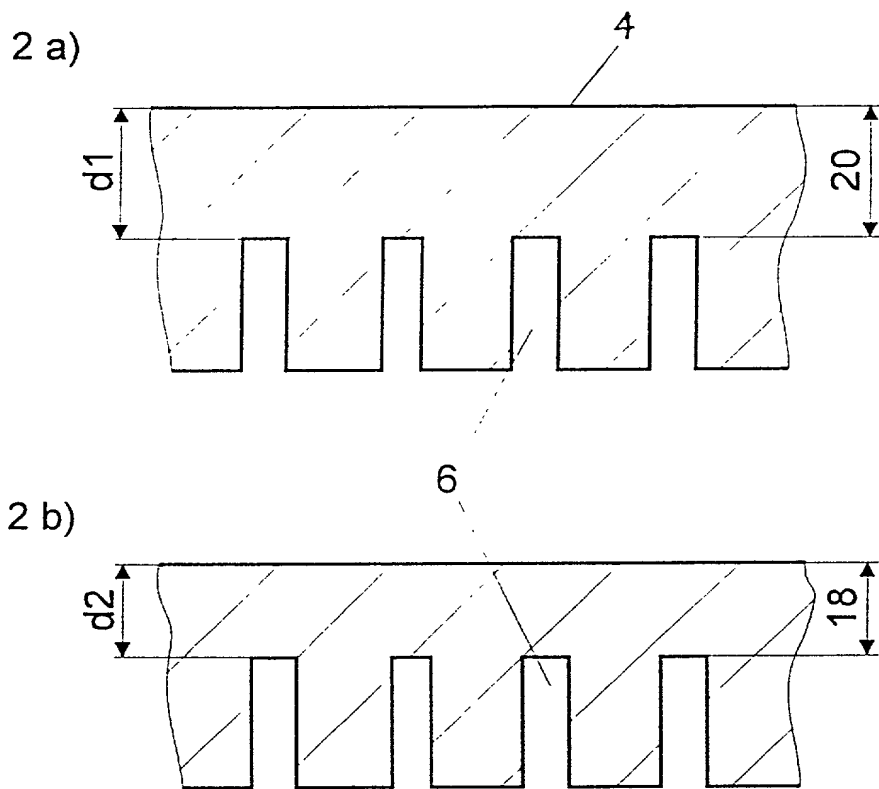


Fig. 2